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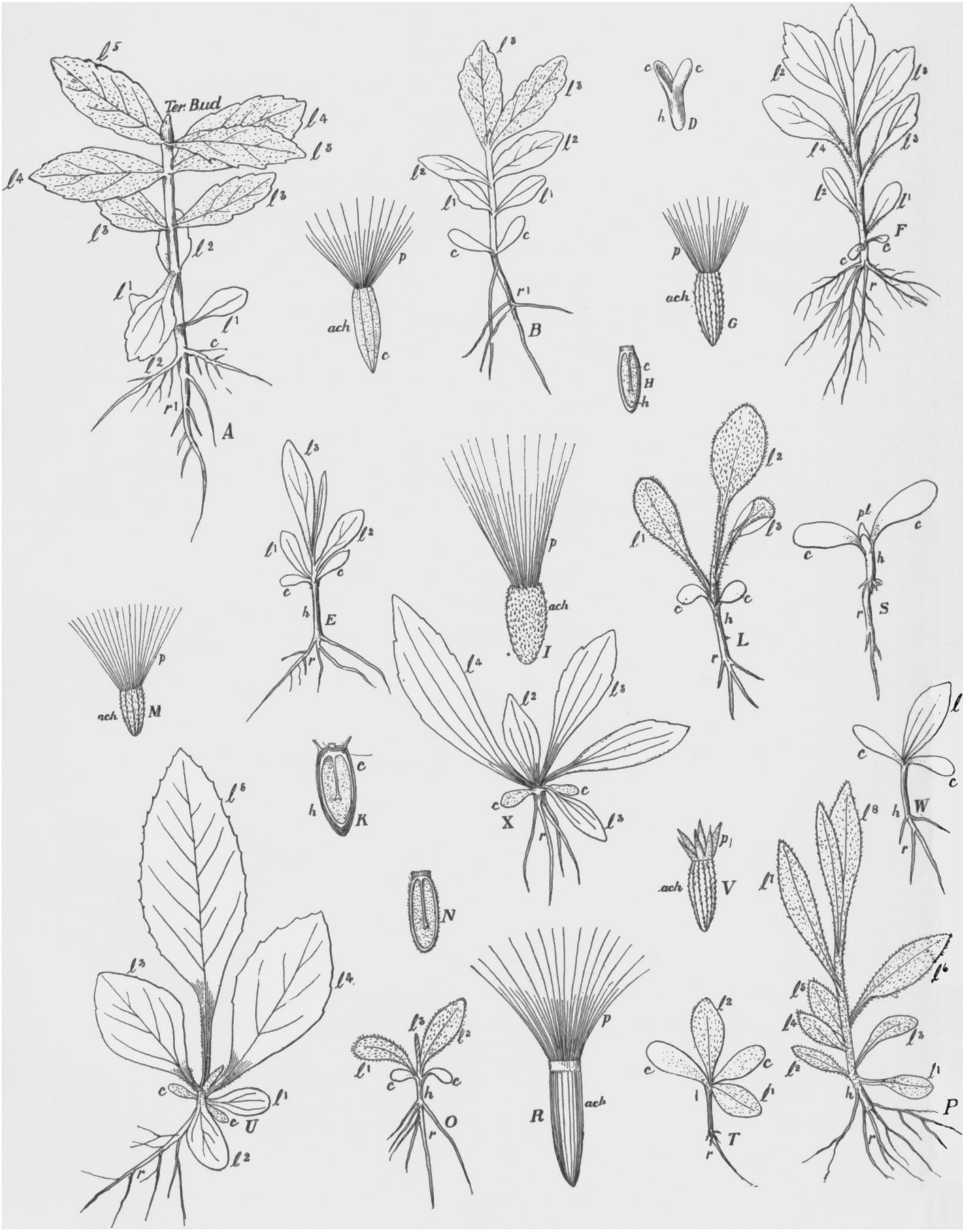
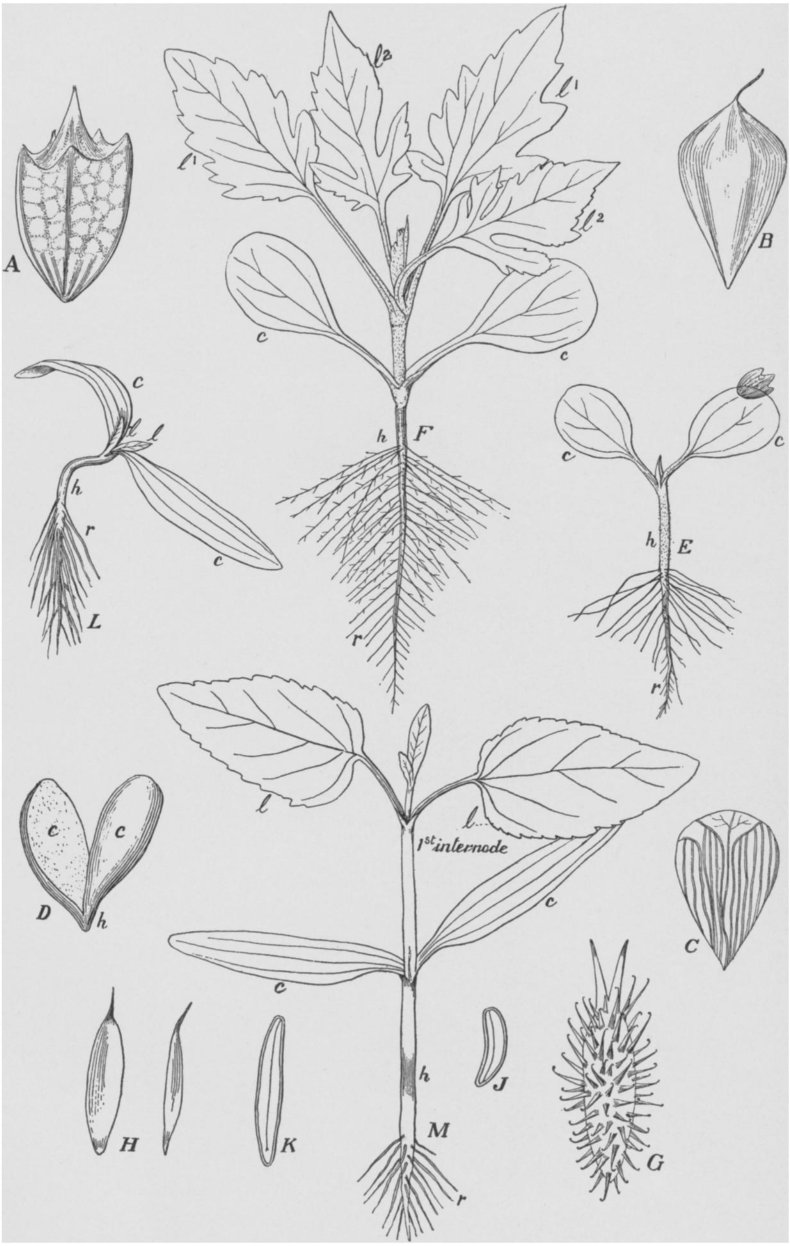
BULLETIN OF THE TORREY BOTANICAL CLUB.—PLATE CXXXIV.



AKENES AND SEEDLINGS OF COMPOSITÆ.



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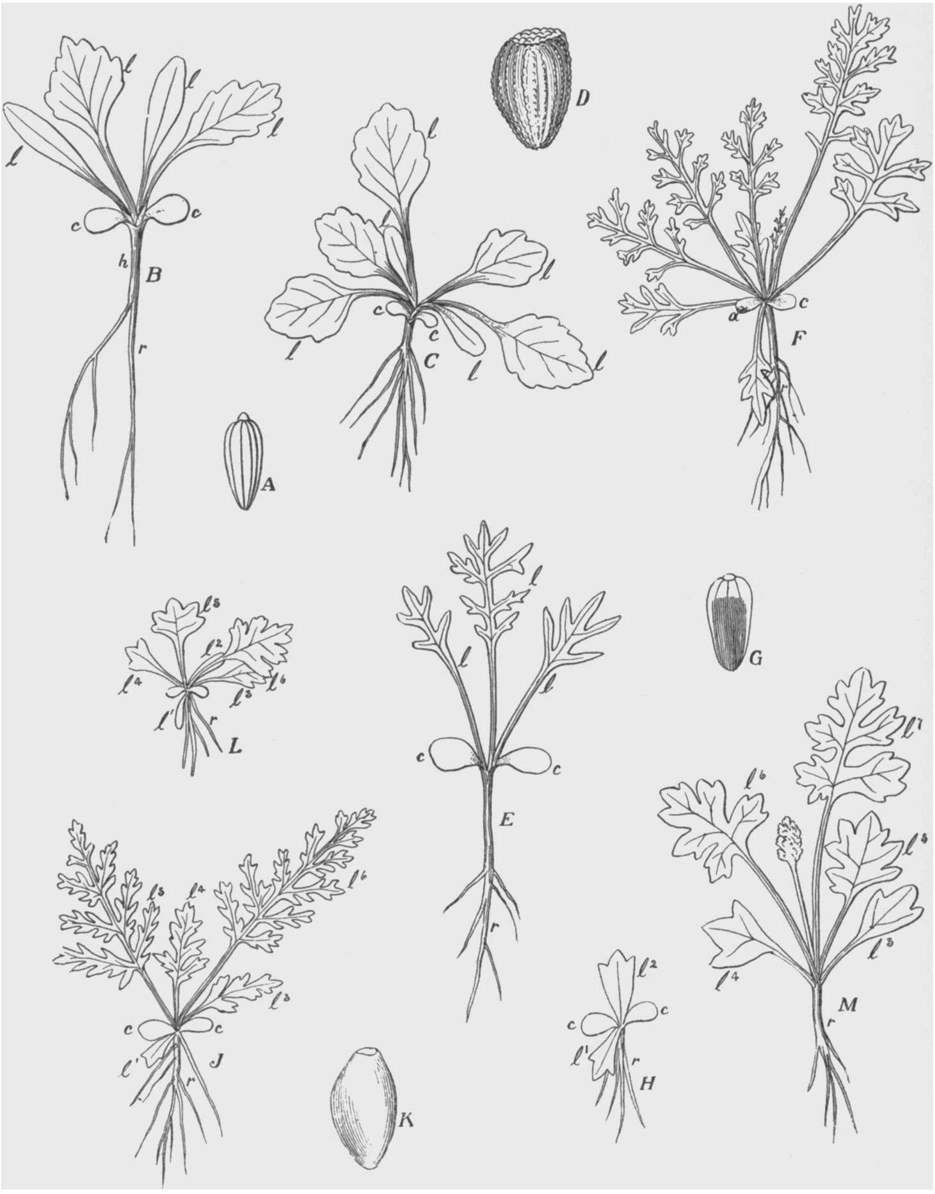

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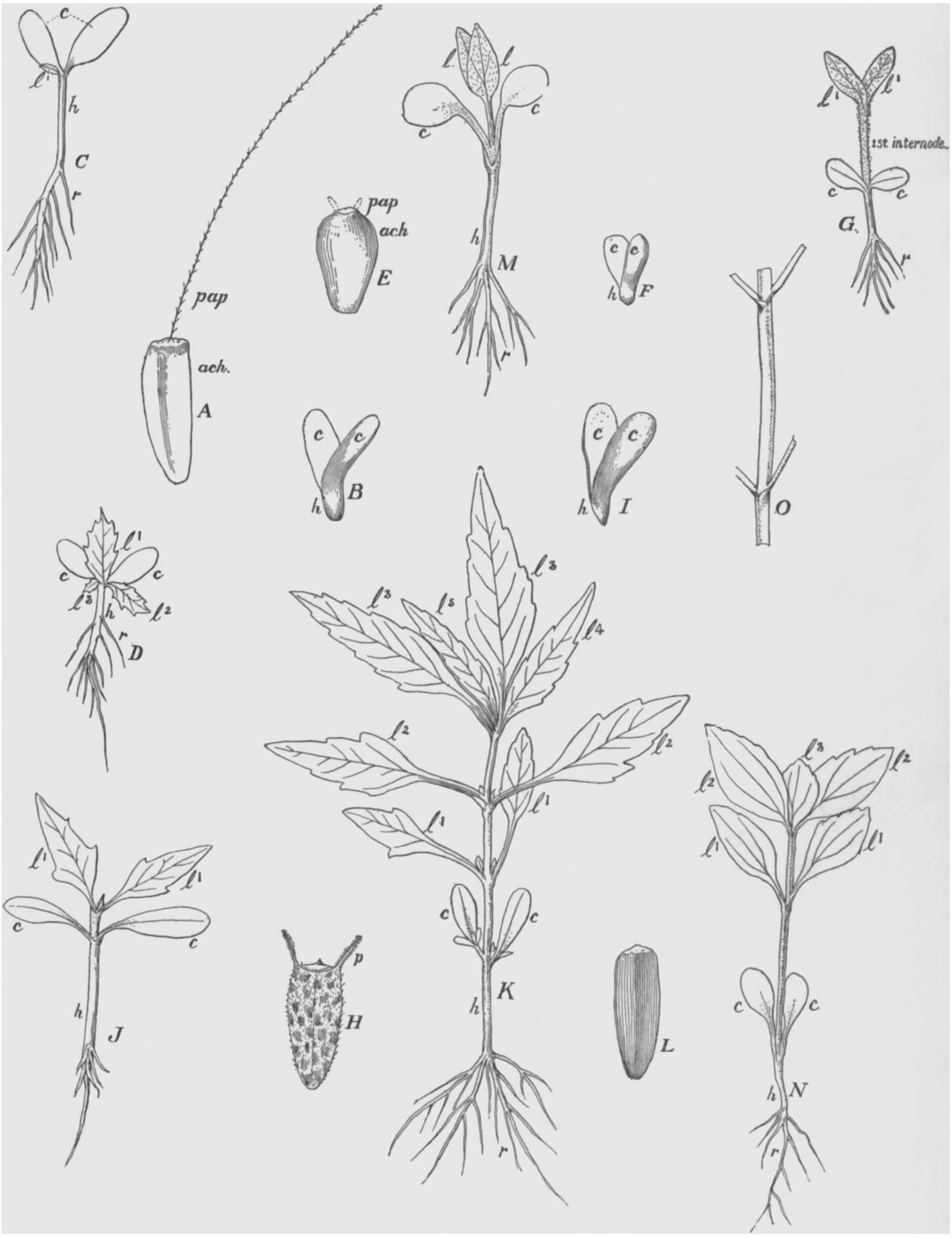
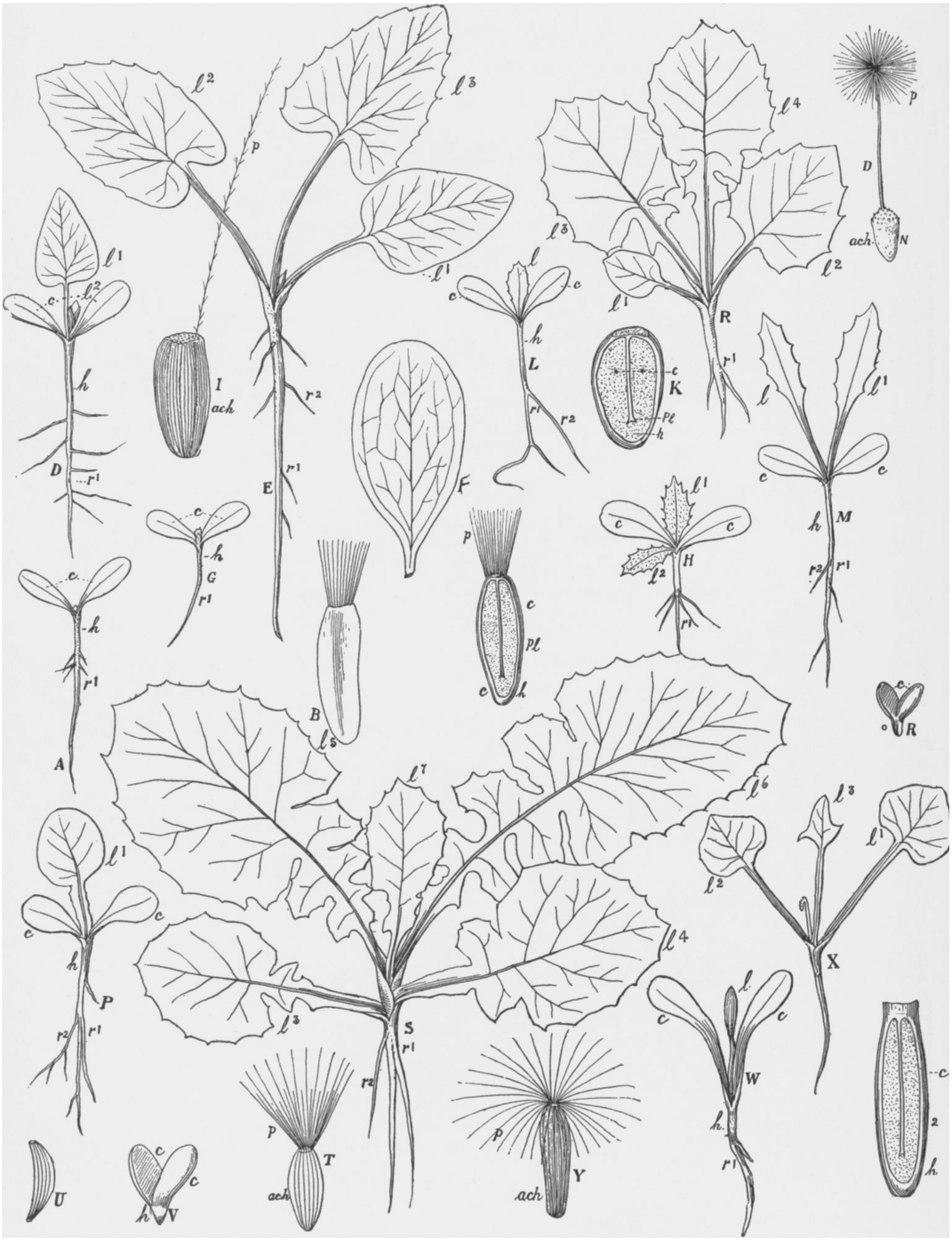


AKENES AND SEEDLINGS OF COMPOSITÆ.

BULLETIN OF THE TORREY BOTANICAL CLUB.—PLATE CXXXVIII.



AKENES AND SEEDLINGS OF COMPOSITÆ.

BULLETIN
OF THE
TORREY BOTANICAL CLUB.

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Studies upon Akenes and Seedlings of Plants of the Order Compositæ.

BY W. W. ROWLEE.

(PLATES CXXXIV.—CXXXVIII.)

General Observations.

The fruit of the plants, belonging to the Order Compositæ is no less remarkable for its variety of external form than for its uniformity in internal structure. In the mature fruit, the calyx and the carpellary coats are completely combined, so that they cannot be distinguished by any structural differences. The integument of the seed may be separated from the others, and is a delicate polished membrane, wrapped rather closely around the embryo. The limb of the calyx, although sometimes obsolete (*Chrysanthemum Leucanthemum et. al.*) more often appears as a crown or cup (*Anthemis arvensis et. al.*) or a set of teeth or scales (*Helenium autumnale et. al.*) or as a tuft of bristles or hairs (*Aster et. al.*) When the limb of the calyx takes on any of these forms it is called the pappus. In *Lactuca, Taraxacum, et. al.*, the pappus is raised far above the akene by a prolongation of the calyx into a slender beak. The akene may be terete, striate, ribbed, angled, or winged. It may be glabrous, hairy, silky, or even spiny. It is usually larger above and tapering downward, but this is not always the case. There is more or less of an opening left at the base of the akene when it falls from the receptacle through which the hypocotyl emerges when the seed germinates. These are but a few of the general ways in which the akene varies externally. To enumerate all the variations would necessitate a description of every species.

The akene is one-celled, containing a single anatropous, exalbuminous seed with a straight embryo. The embryo conforms in shape and size to the enclosing walls. In *Bidens* and *Coreopsis* it is much flattened and narrows abruptly at the base; in *Eupatorium* and *Mikania* it is cylindrical; and in *Helianthus*, *Aster* and *Solidago* and many others it is top-shaped, the cotyledons filling the upper thicker portion of the akene, and these narrowed below into the still narrower hypocotyl. The cotyledons are usually longer and broader than the hypocotyl, but this is not always the case, (as asserted in Gray's Syn. Fl. of N. A., p. 48). In *Ambrosia* the hypocotyl is very small; in *Aster*, *Solidago*, and *Coreopsis* the hypocotyl is larger, but still is much shorter and narrower than the cotyledons; in *Eupatorium* and *Mikania* it is as long, or longer than the cotyledons, and is nearly, if not quite as broad. The plumule is minute, but may be seen in a vertical section of the seed. The cotyledons are closely applied to each other, their faces being in the same plane in which the seed is flattened.

Germination begins by the growth of the hypocotyl, and its first evidence is the protrusion of that organ through the aperture at the base of the akene. The cotyledons enlarge, sometimes splitting the akene and thereby emerging; sometimes, especially in those cases where the akene is small, withdrawing entirely, and leaving the akene a mere shell. Akenes planted out doors in autumn germinate promptly in the spring.

The seedling always has two cotyledons which are nearly or quite alike. They vary in size from an inch long in *Ambrosia trifida* and *Helianthus annuus* to minute in the *Artemisias* and *Chrysanthemums*. They are all the way from nearly sessile in *Chrysanthemum* and *Anthemis* to long-petioled in *Prenanthes* and *Arctium*. The bases of the petioles form a sheath around the plumule when the seedling is young. This sheath is widely dilated in *Anthemis*, but in most cases appears as a continuation of the hypocotyl. The cotyledons, although differing in some respects, display a striking uniformity throughout the order. They vary from spatulate to orbicular; in a majority of cases, however, being oblong. They are entire and usually narrowed abruptly into the petiole. The midvein is usually prominent, and may run to the apex or may fork somewhat below. In some species two lateral veins follow the petiole, diverge at the base of the blade and ramify near the margins of the leaf. They and their branches reticulate with the branches of the midvein. When the lateral veins are not present the branches of the midvein reticulate with each other. The hypocotyl is of considerable length, sometimes slightly flattened. The tap-root, at first well marked, is sometimes lost among its fibrous branches, sometimes maintaining supremacy throughout.

In one species, at least, branches arise normally from the axils of the cotyledons (*Coreopsis discoidea*). In *Anthemis arvensis* branches arise, if not from the cotyledons, from the axils of the first leaves.

In some species the leaves, like the cotyledons, are opposite during the whole life of the plant. The remainder are of the two-fifths arrangement. The first internodes may not elongate; thus is brought about the radical leaved forms. The Phyllotaxy of these, however, may be detected by the sequence of development.

The leaves may immediately assume very nearly the form of the mature plant. This is the case in *Anthemis arvensis.* Usually, however, there is a gradual transition in the first leaves from the cotyledons to the leaves of the mature plant. In *Chrysanthemum Leucanthemum* the first leaves are neither like the cotyledons nor the succeeding leaves.

In general it may be said that the first leaves show a tendency to retain the form of the cotyledons, but have the texture of the later leaves.

The germination of the seeds of annuals and biennials is much more prompt than is the germination of seeds of perennials. A much larger percentage of seeds of the former germinate also. Their seedlings are larger and more capable of withstanding hardships.

Several of the perennial plants of the order flower the first year. *Helenium autumnale* and *Aster Novæ-Angliæ* are among these. The biennials store up food in their tap-root (*Arctium, et al.*), or in the branches of it (*Lactuca*). Their leaves during the first year are radical and are usually of large size.

Germination.

The lines of inquiry undertaken in connection with the germination of seeds were several. Before planting, the percentage of apparently good seed matured by each species was noted. In this case fifty good seed were taken, and the number of unfilled seed found with them, be they more or less, was recorded.

Many fruits are provided with a pappus which serves a two-fold purpose. It acts as a parachute and thereby assists in the dissemination of the seed; further it causes the seed to alight pappus end up, acting like the feathered end of an arrow. Now the parts of the embryo are so arranged that when the seed alights in this manner the cotyledons are up and the hypocotyl down. Thus the parts are placed in the most advantageous position for germination.

The 50 apparently perfect seeds of each species were divided equally, and one-half were planted with the pappus down and one-half with the pappus up. The figures given in the 3d and 4th columns of the accompanying table show the number which germinated in each case.

In the 5th column is shown the number germinated up to June 23. None germinated during the following summer. The seeds were planted the previous autumn (Nov. 23).

Finally the morphology of the seedlings was studied in different stages of development, and the peculiarities recorded in descriptions and drawings.

The seeds of various plants of the Order were gathered, care being taken that they be free from other seeds. Seeds were selected from several vigorous plants some distance apart, where that was practicable. The seeds were then taken from the heads indiscriminately, and carefully examined for any external evidences of poorness, and then by slight pressure with a needle to see whether or not they were filled. From the observations, the following statements may be made.

The number of seeds which, from their general appearance, can be detected as poor, is very variable among different species. In *Aster Novæ-Angliæ* var. *roseus* and *Solidago serotina* the number was large. In *Sericocarpus asteroides*, there were 2½ poor seeds to every good one. Those which ranged from 1½ poor ones to every good one, were *Ambrosia trifida* and *Helenium autumnale*. Two species perfected all of their seeds. These were *Polymnia Canadensis* and *Arctium Lappa*. Of the other species, eight perfected more and four less than one-half of the good seed.

Excluding *Aster Novæ-Angliæ* var. *roseus* and *Solidago serotina* (the poor seeds of which were only estimated), it was found that of the 17 remaining species, 1321 seeds were examined, 900 of which were good, and 471 or not quite 33 per cent. of the whole number were poor. The statements are all based upon a study of the seeds themselves before they were subjected to a test by germination. An estimate of the quality of seeds by a study of the external appearance of the seed itself must necessarily be uncertain, and is bound to overestimate the good seed. The test by germination on the other hand may not give the full value to the vitality of the seed, and can never overestimate the good seed contained. In column 5 is tabulated the number of seeds germinated of the 50 supposed to be good. Four of the 50 assorted or of the 80 unassorted seeds of *Aster Novæ-Angliæ* germinated. 5 per cent. of unassorted, 8 per cent. of assorted, is the rate of germination of this plant. Of the seeds of *Inula Helenium*, 45 germinated. This gives as its rate 70 per cent. of unassorted and 90 per cent. of assorted. The percentages of these and the other species are tabulated in columns 6 and 7.

Of the plants which may be considered as *persistent field weeds*, but two were grown. Their percentage of germination was very large, the first being the highest of all.

Arctium Lappa	78
Taraxacum officinale	19

The *way side and fence row weeds* in the order of their percentage of germination is as follows:

Inula Helenium	70
Heliopsis helianthoides	65
Lactuca spicata	55
Coreopsis discoidea	32
Ambrosia trifida	23
Eupatorium perfoliatum	16
Aster Novæ-Angliæ	5
Solidago serotina	1

The remainder, which may not be characterized as *weeds*, range as follows:

Cnicus muticus	33
Prenanthes Serpentaria	15
Helenium autumnale	13
Sericocarpus asteroides	4
Polymnia Canadensis	2
Gnaphalium obtusifolium	1
Senecio vulgaris	0
Aster Novæ-Angliæ var. roseus	1
Hieracium venosum	0

The general average is:

Persistent field weeds	49
Wayside and fence row weeds	33
Not weeds	8

This is direct evidence that the vitality of seeds of a species is a factor in determining the abundance of the plant and its ability to become a weed.

TABLE SHOWING THE VITALITY OF SEEDS.

SPECIES STUDIED.	Seed apparently perfect.	Seeds not filled.	25 seeds planted, pappus end down. No. germ.	25 seeds pappus end up. No. germ	Total number germinated.	Per cent. germination. Seed assorted.	Per cent. of germ. Seed unassorted.
Aster Novæ-Angliæ	50	30	1	3	4	8	5
Prenanthes Serpentaria	50	40	9	5	14	28	15
Eupatorium perfoliatum	50	29	6	6	12	24	16
Ambrosia trifida	50	63	13	13	26	52	23
Gnaphalium obtusifolium	50	15	1	0	1	2	1
Inula Helenium	50	15	21	24	45	90	70
Polymnia Canadensis	50	0	1	0	1	2	2
Arctium Lappa	50	0	19	20	39	78	78
Solidago serotina	50	Est.	7	13	20	40	1
Coreopsis discoidea	50	28	9	16	25	50	32
Senecio vulgaris	50	5	0	0	0	0	0
Heliopsis helianthoides	50	15	20	22	42	84	65
Sericocarpus asteroides	50	128	3	4	7	14	4
Helenium autumnale	50	70	8	8	16	32	13
Hieracium venosum	50	14	0	0	0	0	0
Taraxacum officinale	50	8	3	8	11	22	19
Cnicus muticus	50	8	11	8	19	38	53
Lactuca spicata	50	3	10	19	29	58	53
Aster Novæ-Angliæ var. *roseus*	50	Est.	7	9	16	32	1

Descriptions of Akenes and Seedlings.

Eupatorium perfoliatum, L. (Plate CXXXIV. A–D.) "Akene 5-angled destitute of intervening ribs." The outer wall minutely perforated, 2 mm. long, black, pappus as long as the akene, of about 20 capillary bristles. Embryo small; hypocotyl as long as or longer than the cotyledons, terete as is the whole embryo when the cotyledons are placed face to face.*

The cotyledons of the seedling plant are small, orbicular, the blade bent at an angle with its petiole. Petiole evident, but not long. Hypocotyl short, tap-root branching early. The hypocotyl soon bears roots up to the very base of the cotyledons. All the internodes lengthen. Leaves opposite. The first, second and third pairs are less and less petioled; the fourth pair are clasping, and the succeeding pairs are more or less perfoliate. The first and second internodes, and the accompaning leaves are less hairy than the remainder of the plant. The third and succeeding pairs of leaves take on more or less of the rugose character of the later ones. They also resemble the leaves of the mature plant in form. The plant does not blossom the first year, but grows to a height of a foot or more.

Solidago serotina, Ait. (PLATE CXXXIV. E–H.) The akene in this species is 10-costate and somewhat hairy, about one and three-fourth mm. long and one-third mm. wide. The pappus is nearly twice as long as the akene. The cotyledons in the seed are longer than the hypocotyl. The embryo tapers toward the base.

In the seedling the cotyledons are rather small, obovate-spatulate, short-petioled, hypocotyl as long as or longer than the cotyledons. The tap-root is soon indistinguishable from the other roots. The first internode elongates but little. The succeeding are gradually longer. The first leaf resembles the cotyledons in shape, but is ciliate along the margin, while the cotyledons are not. The hairs forming the cilia are upon the margined petioles of all the early leaves. They are longest at the sheathing base of the petioles, and grow shorter toward the apex of the leaf. Along the margin of the leaf they form merely a roughness. The early leaves are only faintly triple nerved. The tap-root is soon lost among the multitude of fibrous roots. During the first year's growth no flowers appeared. At the end of the season there was a decided tendency to multiply by underground shoots.

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* The statement made in the "Synoptical Flora of North America," (p. 48), to the effect that the ovule becomes "an exalbuminous seed with a straight embryo, the inferior radicle (hypocotyl) shorter and narrower than the cotyledons" is erroneous. In several, if not all the *Eupatoriums* and in *Mikania scandens*, the hypocotyl is as long as or longer than the cotyledons, and nearly, if not quite as broad.

Sericocarpus asteroides (L.) B. S. P. (Plate CXXXIV. I. K. L.) Akene only slightly compressed, 2-nerved, very silky; hence the generic name; 2 mm. long, 1 mm. broad; pappus more than twice the length of the akene, unequal, ferruginous. Embryo in vertical section, obovate. Cotyledons three times as long as the hypocotyl.

The seedling has small cotyledons. These are elliptical, or nearly orbicular, and smooth, petioled. Hypocotyl short. Tap-root prominent. The first leaf assumes the general characteristics of the later leaves. They are hairy above, smooth below, and ciliate along the margin of the blade and petiole.

Aster Novæ-Angliæ, L., var. *roseus*, Gray. (Plate CXXXIV. M–P.) Akene compressed, hairy, 10-ribbed, ovate, one-half as long as the soft pappus. Embryo with flattened cotyledons more than twice the length of the abruptly downward tapering hypocotyl.

Seedling with short hypocotyl. Cotyledons orbicular, small, smooth, short petioled. First four or five leaves narrowed to a petiole. The later leaves clasping. They, as well as the stem, pubescent. First internodes lengthening only slightly; the later much longer. Roots appear on the hypocotyl, and the tap-root is soon lost among them. Both this plant and the type *Aster Novæ-Angliæ* blossom during the first year. The seedling of this variety differs in no respect from that of the species unless it be that the lower leaves are narrower, and the clasping ones more narrowed above the auricled base. It would be necessary to observe more specimens before setting this down as an established fact.

Inula Helenium, L. (Plate CXXXIV. R. S. T. U.) Akene linear, obtuse at base, obscurely four-sided, striate, crowned at the top with the united bases of the pappus hairs. Pappus long (8 mm.) straw color, widely spreading from the top of the akene. Embryo subcylindrical, cotyledons twice the length of the hypocotyl.

Seedling medium in size. Cotyledons oblong, more than twice as long as broad; short-petioled, smooth; hypocotyl short; tap-root long and becoming thickened early; the first two leaves hairy, broader and longer petioled than the cotyledons. Although the leaves are of two-fifths arrangement, the first two twist sufficiently to stand nearly at right angles to the cotyledons. Internodes not elongated, hence the leaves appear in a rosette. The 3d and 4th leaves are obscurely sinuate-toothed, ovate, rugose, hairy, especially beneath. The succeeding ones are lance-elliptical, more conspicuously sinuate-toothed, long-petioled.

The plant shows no signs of flowering the first year. The tap-root thickens, however, preparatory to flowering the following year.

Helenium autumnale, L. (Plate CXXXIV. V. W. X.) Akene small, 8 or 10-costate, hairy, turbinate, crowned with the pappus which consists of 5 or 6 chaffy pointed scales about one-half as large as the akene.

Seedling mediocre, cotyledons oblong, about one-half as broad as long, short petioled. Hypocotyl longer than the cotyledons· Tap-root long, soon overtaken by the fibrous roots and lost among them. The seedlings resemble young plants of Ribgrass (*Plantago lanceolata*, L). The first and second leaves are elliptical and the succeeding are elliptical-lanceolate, 5-nerved, sparingly toothed. The plant is smooth throughout. The leaves although in a rosette, are evidently of the two-fifths arrangement. Seedlings flowered during the first year's growth.

Ambrosia trifida, L. (Plate CXXXV. A–F.) The "fruit" of this species consists not only of the akene as found in other composites, but is made up of the akene closely and completely invested by the gamophyllous involucre. It is "nut-like," beaked at the top and crowned by five or six short spines in a single series below the beak. The embryo is large and oily, obpyriform. It has a caruncle-like appendage at the inferior end of the hypocotyl. The cotyledons are thick and large; the hypocotyl small and tapering abruptly downward.

The seedlings are large, equalling in size the seedlings of *Helianthus annuus*. The cotyledons are nearly orbicular, thick, reticulate veined, narrowed at base into a short sheathing petiole. The hypocotyl is long and slightly flattened. The tap-root maintains supremacy throughout the life of the plant. The many rootlets given out at the junction of the tap-root and hypocotyl are followed by many similar ones from all parts of the primary root. The hypocotyl sometimes attains a length of two inches, but not often more than that. The cotyledons are at length borne on petioles as long as their blades. The first pair of leaves are obtuse, sometimes trifid, but more often only toothed. Sometimes one of the first pair of leaves will be trifid, the other not. The succeeding leaves are of the same nature as those of the mature plants. The leaves show a gradation from the rounded apex of the cotyledons to the acuminate final leaves. The plant is an annual.

Ambrosia artemisæfolia, L. The seeds and seedlings of this species differ from *A. trifida*, L, principally in size. The cotyledons, hypocotyl and root are less than one-half as large as the same parts in the larger plant. Another difference of much importance in determining the character of the plant, is the presence of buds in the axils of the lower leaves and cotyledons, and their early development into branches. Thus, early, is the diffuse nature of the plant determined. The buds of the lower axils, moreover, must be one of the characters by which the plant maintains its reputation as a persistent weed. The first pair of leaves are "trifid" or not; sometimes one is "trifid," the other not. The lobes of the leaves in *A. artemisæfolia* are more rounded than in *A. trifida* from the very first.

Xanthium Canadense, Mill. (Plate CXXXV. H–M.) There are two akenes contained within the bur-like involucre of each pistillate head. The akenes are plano-convex, the plane side toward the axis of the head. They are black, elliptical, and tipped with the long protruding, but withered style. The cotyledons of the embryo are slightly dissimilar, the one on the convex or outer side being somewhat thicker than the other. The hypocotyl is very short, not more than one-sixth the length of the cotyledons.

The seedling emerges from the bur in the same manner as the seedling of *Ambrosia*. Both akenes in a single head frequently germinate, usually not at the same time, however, so the seedlings will be at two stages of growth. The hypocotyl lengthens considerably. The conspicuous tap-root gives off numerous branches. The cotyledons are lanceolate, obtuse, somewhat narrowed at the base, strongly triple nerved. The first two leaves are nearly opposite; the succeeding become more and more distinctly alternate until, as in the mature plant, they are of the alternate type.

Seedlings, before the first leaves develop, have the hypocotyl bent nearly at right angles, thus causing its upper part and the cotyledons to lie upon the surface of the ground. At this stage of their growth there is every indication that the plant will be prostrate. It very soon straightens up, however, and by the time the first leaves are fully developed it is entirely erect. How the plant has come to assume this peculiar habit it is difficult to see.

Anthemis arvensis, L. (Plate CXXXVI. D. E. F.) Akenes roughly ribbed, not flattened, "crowned with a very short slightly toothed margin in place of a pappus."

Seedling with nearly sessile oblong cotyledons. Hypocotyl comparatively long. Tap-root evident. First two leaves pinnate. The succeeding bipinnate. The change from cotyledons to lobed leaves is abrupt.

The plant is a winter annual, that is from a plant ripening in July, seeds germinate the same autumn and remain over winter as seedlings. *A. Cotula*, L. (May weed) is, on the other hand, a summer annual. It ripens its seeds in autumn, and these do not germinate until the following spring and early summer.

Chrysanthemum Leucanthemum, L. (Plate CXXXVI. A. B. C.) Akene small (2 mm. long by ¾ mm. wide) 8 to 15-costate.

The costæ white, the intervening spaces black. Pappus none.

Cotyledons of seedlings small, short-petioled, the petioles united at the base into a short sheath; blade oblong, thick. First two leaves spatulate, entire, borne on petioles nearly as long as the blade. The later leaves are like the radical leaves of the mature plant. The first and second leaves in this species can hardly be said to be intermediate in form between the cotyledons and the succeeding leaves.

Achillea Millefolium, L. (Plate CXXXVI. G. H. J.) Akene obcompressed, margined, small. The margin white; pappus none.

Cotyledons small, nearly orbicular, closely sessile. First two leaves small, tridentate, or the second one with two pairs of lateral leaflets. Succeeding leaves like the leaves of the mature plant.

Artemisia Absinthium, L. (Plate CXXXVI. K. L. M.) Akene not flattened, obovate, smooth; pappus none.

Seedlings small. Cotyledons closely sessile, 2 mm, long by 1 mm. wide. First two leaves linear-oblong, thickish, entire. The third and frequently the fourth tridentate, the succeeding coarsely toothed, finally compound. These seedlings may be distinguished from those of *Achillea* by the second and third leaves being oblong, entire; and from *Chrysanthemum* by the third and fourth leaves being tridentate.

Heliopsis helianthoides (L.) B. S. P. (Plate CXXXVII. L–O.) Akene without pappus, 3 or 4 angled [Triangular in the ray (Syn. F. of N. A.)]. Embryo only slightly flattened.

Seedling of medium size. Cotyledons bent at the union of the blade and petiole, blade nearly orbicular, petioles as long as their blade. Leaves opposite, the first pair ovate-lanceolate. They and the succeeding minutely hairy, scabrous above, smooth below; the later pairs ovate, somewhat toothed. The stems of seedlings have two pubescent lines running from the axil of each leaf to the next node above. The lines like the pairs of leaves decussate, those of any internode being half way round the stem from the lines of the internode below or above. The plant produced a few flowers during the first year's growth.

Helianthus divaricatus, L. (Plate CXXXVII. E. F. G.) Seedlings of this species differ very much in appearance from those of the common sunflower (*H. annuus*). They are slightly hairy, small and slow of growth. The akene is top-shaped, smooth. Hypocotyl of embryo short and narrower than the cotyledons.

Seedlings with short petioled cotyledons. These are ovate and thick. The first internode elongates. First pair of leaves elliptical, sessile, ciliate, veiny. The seedlings of this plant differ from those of *Heliopsis* in the shape of the cotyledons, length of their petioles, and in having the stem uniformly hairy instead of hairy in lines as is so conspicuously the case in *Heliopsis*.

Coreopsis discoidea, Torr. and Gray. (Plate CXXXVII. H–K.) Akene much flattened with 2, 3 or 4 upwardly barbed awns at the summit, somewhat hairy; embryo much flattened; cotyledons oblong, twice as long as broad, narrowed rather abruptly at the base into the short slender hypocotyl.

The seedlings of this species and of *Ambrosia* germinated very promptly in the spring. The cotyledons are oblong, petioled. Hypocotyl long, bearing a few roots at its union with the tap-root. Branches developed from the axils of the cotyledons as well as the succeeding leaves, thus early determining the diffuse character of the mature plant. The first pair of leaves sparingly toothed, longer petioled than the cotyledons. The later leaves longer petioled and less sparingly toothed. The plant is an annual.

Cnicus arvensis (L.) Hoffm. (Plates CXXXVII. B. C. D.) Seeds are not produced in abundance in the vicinity of Ithaca, yet by a little search plenty can be found. They have a long plumose pappus, are smooth and only obscurely angled.

The seedlings with which this obnoxious weed begins its life history are innocent-appearing enough. The cotyledons although very like those of *C. lanceolatus and C. muticus* are very small. The first leaf is spiny on the margin, the succeedings ones becoming larger and more spiny. Roots are given off throughout the length of the hypocotyl. The cotyledons have no prominent mid-rib; they are ovate, fleshy and obscurely reticulate-nerved. The early leaves are in a rosette.

Arctium Lappa, L. (Plate CXXXVIII. A–F.) The akene of the Burdock is flattened parallel to the faces of the cotyledons. The pappus is about one-half its length and is deciduous. It is black and blistered. The hypocotyl in the seed is very short; the cotyledons are large, filling the greater part of the seed.

The seedling is rather large, and, like the mature plant, very tenacious of life. The hypocotyl is short, only about one-fourth the length of the tap-root, and one-half as long as the cotyledons. Prior to the development of leaves from the plumule, the tap-root branches very sparingly, and mostly at the point of union of root and hypocotyl. It evinces a disposition from the first to become thickened. The cotyledons are sheathing at the base, fleshy, oblong-spatulate, obscurely emarginate, pinnately nerved, the lateral nerves visible only after the tissue has been cleared by soaking in alcohol. Plumule not developed sufficiently to protrude from the sheathing bases of the cotyledons. The seedling even at this early stage emits the peculiar odor of the mature plant.

The first leaf is intermediate in form between the cotyledons and the mature leaves. It is ovate, obtuse, truncate or subcordate at base, sparingly denticulate. The petiole is nearly or quite as long as the leaf. The succeeding leaves are cordate, denticulate, pinnately veined. The plant is strictly biennial. During the first year there is no elongation of internodes, consequently the leaves are all radical. The tap-root thickens and elongates, but at no time is it profusely branched. The hypocotyl disappears, and the tap-root appears to extend up to the bases of the leaves.

Cnicus muticus (Michx.) Pursh. (Plate CXXXVIII. G–K.) The akene is dark-colored, obovate and smooth; pappus long-plumose. The cotyledons and very small hypocotyl are oily in the seed.

The cotyledons, when developed, are obovate, entire, rounded at the apex, tapering toward the base, reticulately veined, with well-marked mid-rib. Hypocotyl short; tap-root long, only slightly branched.

The first leaves are hairy on both sides, and, like the mature plant, bear prickles along their margins. The succeeding leaves take on more and more the runcinate character of the radical leaves of the mature plant. During the first year's growth the internodes do not elongate. The tap-root thickens and branches considerably.

Taraxacum officinale, Web. (Plate CXXXVIII. L–O.) The fruit of the Dandelion consists of three parts, the akene, the beak and the pappus. The beak is for the most part a growth which takes place after the flower has withered. The akene is short, spiny above, obovate, somewhat flattened in the plane of the faces of the cotyledons. The hypocotyl is terete, about one-third the length of the cotyledons. The latter are one-half as wide as long, and when placed face to face, as in the akene, they are sub-cylindrical.

In the seedling the cotyledons are small (5 to 8 mm.), obovate-spatulate, apex rounded. The hypocotyl is as long as the cotyledons; tap-root long, somewhat branched. The first leaves are sinuately toothed. Only the later take on the "dens de leonis" character. The tap-root thickens and branches, but retains supremacy during the life of the plant.

The plant does not blossom the first year. Several leaves appear, but in the seedlings grown there is no indication of a flowering scape. As is well-known, there is never any elongation of internodes in this species.

Prenanthes Serpentaria, Pursh. (Plate CXXXVIII. W. X. Y. Z.) Pappus straw-colored, spreading horizontally from the top of the akene at maturity. The akene awl-shaped, slightly flattened, dark brown. The cotyledons six times the length of the hypocotyl.

The cotyledons of the seedlings are raised upon petioles longer than their blades.* The blade is spatulate, bent at right angles with the petiole at their junction. The petioles unite at their base to form a sheath around the plumule. The hypocotyl is shorter than it appears to be on account of the united bases of the cotyledons appearing as its upper end. Tap-root prominent, not diffusely branched. First and second leaves, long-petioled. Petioles red, not margined. Blade broadly ovate, slightly lobed or toothed. Third and succeeding leaves deltoid as are the radical ones of the mature plant.

Prenanthes alba, L. Like the preceeding species except in the seedlings grown the several parts were smaller and less inclined to be colored.

Lactuca spicata (L.) Hitchc. (Plate CXXXVIII. P–V.) Fruit not beaked, differing in this respect from some of the species of this genus. Pappus one and a half times the length of the akene, dirty white, of about 30 capillary bristles. Akene flattened and ribbed. Seen from the side it is ovate-elliptical; from the edge, lunate. The embryo, in conformity with the seed, is much flattened, obovate; the cotyledons are three or four times the length of the hypocotyl.

The seedling is small; cotyledons elliptical, sparingly hairy, reticulately veined; hypocotyl short, one-half the length of the cotyledons; tap-root branching early.

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*I have in my possession a seedling plant of this species which has the petioles of the cotyledons united up to the blade on one side. The close cohesion of the lower portions of the cotyledons in the seed seems to indicate that this might often occur.

W. W. R.

The first leaf is strikingly different from the cotyledons. It is petioled, the petiole wing-margined, nearly or quite as long as the blade. Blade orbicular, entire, erect, roughish. The second leaf petioled like the first, the blade broadly ovate, sinuate-toothed, subcordate, pinnately veined. The third leaf toothed along the margined petiole, and the succeeding leaves becoming more and more runcinate. The tap-root is branched, it and its branches become fleshy-thickened during the first year's growth. The plant does not blossom during its first year's growth. It is strictly biennial.

Abbreviations Used in the Plates.

c.	cotyledons.
h.	hypocotyl.
r^1.	tap-root.
r^2.	branches of tap-root.
pl.	plumule.
p.	pappus.

l^1. l^2. l^3. etc., first, second, third, etc., leaves. I prefer to call the first leaf above the cotyledons the "first leaf" and let the cotyledons retain their special name.

Plate CXXXIV.

Eupatorium perfoliatum, L.

A. Seedling from which the cotyledons have fallen (x 2). B. Younger seedling with cotyledons (x 2). C. Fruit (x 10). D. Embryo removed from coats (x 10).

Solidago serotina, Ait.

E. Seedling (x 2) with cotyledons and first three leaves developed. F. Same still more developed (nat. size). G. Akene (x 10) with pappus. H. Vert. sect. of same (x 10).

Sericocarpus asteroides (L.) B. S. P.

I. Akene (x 10) with pappus. K. Vert. sect. of same (x 10). L. Seedling with first three leaves developed (x 2).

Aster Novæ-Angliæ, L. var. *roseus*, Gray.

M. Akene (x 5). N. Vert. sect. of same. O. Seedling with first two leaves (x 2). P. Same older (x 2).

Inula Helenium, L.

R. Akene (x 10). S. Seedling (x 2). T. and U. Same in later stages T. (x 1½), U. (nat. size).

Helenium autumnale, L.

V. Akene (x 10) with chaffy pappus p. W. Seedling (x 2). X. Same older (x 2).

Plate CXXXV.

Ambrosia trifida, L.

A. The nut-like fruit (x 4). B. The akene with involucre removed. C. The seed with the ovary coats removed. D. The embryo. E. Seedlings with cotyledons fully developed. F. An older seedling. E. and F. nat. size.

Xanthium Canadense, Mill.

G. Fruit with hooked prickles (x 2). H. Akene from side and edge. J. Cross sect. of cotyledons. K. Vertical sect. of same. L. Seedling. M. Same older. L. and M. nat. size.

Plate CXXXVI.

Chrysanthemum Leucanthemum, L.

A. Akene (x 8). B. Seedling (x 3). C. Same, older (nat. size).

Anthemis arvensis, L.

D. Akene (x 10). E. Seedling with first three leaves (x 2). F. Same, older (nat. size).

Achillea Millefolium, L.

G. Akene (x 10). H. Seedling (x 5). J. Same, older (x 5).

Artemisia Absinthium, L.

K. Akene (x 12) L. Seedling (x 3). M. Same, older (x 5).

Plate CXXXVII.

Cnicus arvensis (L.) Hoffm.

A. Akene (x 10). B. Embryo (x 10). C. Seedling (x 5). D. Same older.

Helianthus divaricatus, L.

E. Akene (x 3). F. Embryo (x 3). G. Seedling (nat. size).

Coreopsis discoidea, Torr. and Gr.

H. Akene (x 6). I. Embryo removed from coats (x 8). J. Seedling (x 2). K. Same older (nat. size).

Heliopsis helianthoides (L.) B. S. P.

L. Akene (x 5). M. Young seedling (x 2). N. Same older (nat. size). O. Internode of stem with two pubescent lines running from the axil of the leaf to the point (on the next node above,) between the bases of the leaves.

Plate CXXXVIII.

Arctium Lappa, L.

A. Seedling with cotyledons fully developed. B. Akene (x 3). C. Vertical section of akene. (x 3). D. Seedling with first leaf developed. E. Seedling with first three leaves developed. F. Cotyledon (x 5).

Cnicus muticus (Michx.) Pursh.

G. Seedling with cotyledons fully developed. H. Seedling with first two leaves l^1 and l^2 developed I. Akene (x 5). K. Vertical section of same.

Taraxacum officinale, Web.

L. Seedling (x 2) with cotyledons fully developed. M. Later stage of same with first two leaves l^1 l^2 developed. N. Akene (x 4). p. beak. O. Embryo (x 6) removed from its coats and with cotyledons spread apart.

Lactuca spicata (Lam.) Hitch.

P. R. and S. successive stages in the devolopment of seedling. S. Magnified three times the others natural size. T. Akene. U. Same (edge) (x 5). V. Embryo removed from coats (x 5).

Prenanthes Serpentaria, Pursh.

W. Seedling (x 3) X. Same at later stage (nat. size). L. Akene (x 5). Z. Vertica sect. of akene (x 7).